

# NanoTech

## Important Commercial Nanomaterials Include Gold

Four types of nanoparticle materials, including gold, accounted for more than 90% of the market in 2006 according to a new report, 'Nanostructured Materials for the Biomedical, Pharmaceutical and Cosmetic Markets' from BCC Research ([www.bccresearch.com](http://www.bccresearch.com)). Titanium dioxide, zinc oxide, and calcium phosphate were other dominant materials. The global market for nanoparticles in biomedical, pharmaceutical and cosmetic applications was worth \$204.6 million in 2007 ●

## Gold Nanotechnology Used for Fingerprint Checks

As we all know fingerprints are key evidence in tracing criminals, but often forensic officials can find it hard to get a print that has faded due to water contamination. When a fingerprint is damaged by water, small residues of fatty acid can remain. Now, it appears, forensic officials can still get a print according to a research team at the Asian Institute of Technology (AIT) whose technology uses chitosan combined with gold nanoparticles. Researchers now plan to extend the technology to detect addictive drugs from fingerprint marks. Similar work is being carried out by Scientists at the University of East Anglia. In this case the researchers are aiming to produce a solution that can detect a range of substances and produce a different colour for each, so it will be possible to look at a fingerprint and obtain a lifestyle profile from it ●

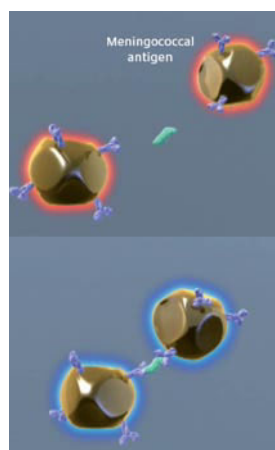
WORLD GOLD COUNCIL

# GOLD news

ISSUE No. 4

SPRING 2008

## Meningococcal Disease Diagnosis Using Gold



One of the leading technologies under development by Quintain NanoSystems ("Quintain NS") is based upon the use of nanoparticulate gold for the rapid diagnosis of meningococcal disease.

Nanoparticles of gold are conjugated to antibodies that are specific to *Neisseria meningitidis* surface proteins. When these disease-causing bacteria are present, the

antibody/antigen binding events can be detected using a variety of techniques including the Surface Plasmon Resonance (SPR) effects of gold at the nanoscale, where an immediate colour change occurs in the visible spectrum, upon clustering of the particles. Other techniques under assessment include monitoring weight changes as a result of the biological binding event, and also changes in the samples magnetic field using gold-coated magnetic nanoparticles. Each of these techniques provides a rapid means of detection for medical staff, with test results being obtained in under 15 minutes. Current techniques often rely



on culture of *Neisseria meningitidis* from either blood or cerebrospinal fluid (CSF) and take between 2 and 48 hours, delaying the administration of antibiotics.

Quintain NS has recently filed a patent, which covers the development of a novel antibody for this specific application, in addition to device formats using the nanoparticle-based diagnostic technology and are also currently working with Melbourne-based company Charwood Design, to develop a prototype clinical device, which will incorporate a safe mechanism for sample [Continues on page 2]

(Continued from page 1)

handling and delivery. The test for meningococcal disease is expected to be available in 2-3 years, with the nanoparticulate gold diagnostic platform adapted for a range of other clinically important diseases shortly thereafter.

Dr Jeanette Pritchard  
Manager, Diagnostics and Imaging  
Quintain NanoSystems and Nanotechnology Victoria

[www.nanovic.com.au/quintain](http://www.nanovic.com.au/quintain) ●

## FDA Clears Genetic Test Using Gold Nanoparticles

Nanosphere, Inc., a nanotechnology-based molecular diagnostics company, has announced FDA clearance of the first test to determine an individual's ability to metabolize the anti-coagulant medication warfarin, information critical to determining safe and appropriate dosing. Warfarin is the most prescribed oral anticoagulant in North America and Europe with more than 12 million new prescriptions from July 2006 to June 2007 and it is the second most common drug, after insulin, implicated in emergency room visits for adverse drug events.

The Verigene System produced by Nanosphere uses patented gold nanoparticle technology to detect nucleic acid targets in a multiplex format. Additional information is available at [www.nanosphere.us](http://www.nanosphere.us) ●

## Crystal Structure of a Gold-Thiolate Cluster Revealed

Scientists have been using thiol-coated nanocrystalline gold clusters since the mid-1990s, but until now the absolute structure of these materials has not been determined. Now Roger D. Kornberg and co-workers have used X-ray crystallography to determine the structure of a nanoparticle composed of exactly 102 gold atoms surrounded by 44 p-mercaptobenzoic acid groups. Thiol-protected gold nanoparticles could find their way into molecular electronics, sensors, and biomedical diagnostics.

For more information see <http://pubs.acs.org/cen/news/85/i43/8543notw4.html> and Science 2007, 318, 430 ●

## Gold Nanoparticles Boost Electronic Memory



Taiwanese researchers say they have developed a simple, durable, and potentially inexpensive nonvolatile memory array made from a mix of plastic and gold nanoparticles. The new memory consists of gold nanoparticles mixed into a polymer called PCm, sandwiched between two aluminium electrodes. The array is a 16-byte device called an organic non-volatile bistable memory. The researchers, from National Chung Hsing University (NCHU) and the Industrial Technology Research Institute (ITRI), presented details of the device at the 2007 IEEE International Electron Devices Meeting. The Taiwanese team plans to integrate the memory into smart cards. See <http://www.spectrum.ieee.org/dec07/5769> for more information ●

In a separate development, researchers in Korea and Australia have used stacked layers of gold nanoparticles to boost the storage density of flash memory. Flash memories, like those found in USB sticks and memory cards for digital cameras, normally contain just a single layer of devices that trap electric charge and thereby encode digital information. Jang-Sik Lee and co-workers at Kookmin University in Seoul and Frank Caruso of the University of Melbourne, have used gold nanoparticles as their charge trap devices, depositing them in alternating layers with an insulating polymer onto a base of hafnium oxide coated silicon substrate. This led to an increase in the memory density of approximately 3.5 times in comparison to the single layered devices, See J-S Lee et al., *Nat. Nanotech.*, 2007, DOI: 10.1038/nnano.2007.380 for more information ●

## National Toxicology Program Confirms NanoGold Testing

It was recently reported that the U.S. National Toxicology Program was considering a major test program to establish if any health risks exist from using nanogold, particularly in biomedical applications. The meeting to discuss this program has now taken place and is available for public consumption: <http://ntp-server.niehs.nih.gov/ntp/meetings/2007/bsc/20071206/videos/08-gold.mov>. In summary, the Scientific Board of the NTP unanimously recommended embarking on a test program and this will now go ahead over the coming months ●

## BBI Partners with NIST to Develop the 'Gold Standard' in Nanoparticles



BBIInternational's gold nanoparticles have been selected by the National Institute of Standards and Technology (NIST) as the source for a series of certified reference materials for pre-clinical biomedical research.

NIST, which is a US federal agency, will use BBIInternational's colloidal gold nanoparticles to create nanoscale reference materials for the evaluation and qualification of methodology and instrument performance. This means that companies involved in the fields of research and diagnostics will be able to ensure that their equipment is performing within the required QC parameters for the measurement and characterisation of quality nanoparticles.

Commenting on the collaboration, Lyn Rees, CEO of BBIInternational's Diagnostics Division said: "We are delighted that our gold has been recognised by NIST as the reference standard in this category. Everything we do at BBI is governed by quality and this collaboration with NIST further supports the 'Gold Standard' reputation that BBI gold has worked hard to achieve within the industry."

BBIInternational's gold colloid is produced using a unique recipe and quality process which allows production of gold colloid in pre-determined sizes, with optimum roundness, uniform shape, and less than 8% CV for cluster free, stable gold to enhance sensitivity and performance. The company has built a strong customer base throughout the world providing reagents and services to a client base spanning small universities through to blue chip diagnostic industry leaders. For further information contact the company on +44 (0) 29 2074 7232 or e-mail [lisacook@bbigold.com](mailto:lisacook@bbigold.com)



## Grant for Female Scientists Working with Gold

Dr. Rahina Mahtab, an associate professor at South Carolina State University, and her research team have recently been awarded a National Science Foundation grant of more than \$320,000, co-funded by the S.C. Experimental Program to Stimulate Competitive Research and Institutional Development Awards. The team's research will centre on the use of gold nanoparticles in biomedical applications. Dr. Catherine Murphy, a University of South Carolina professor will be a collaborator in this research

## Gold Nano-Fillings?

Dental sensitivity can occur when fluid movement in dentinal tubules (microscopic canals that run from the outside of the tooth to the nerve inside) promotes mechanical deformation of nerve endings.

Chinese researchers have demonstrated that dental tubules can be blocked with the aid of gold nanoparticles. See Ming-Han Liu et al 2007

*Nanotechnology* **18** 475104



## Nanopartz Releases a New Line of Highly Monodisperse Gold Nanorods

Utilizing exclusively licensed patent pending technologies developed by Dr. Cathy Murphy at the Univ. of South Carolina, Nanopartz, a division of Concurrent Analytical Inc., has released a new line of highly monodisperse gold nanorods. These nanorods are particularly suited to diagnostics as well as biomedical imaging and photothermal therapy applications. Nanopartz can manufacture nanorods with aspect ratios from 1.67 to 4.5, resulting in absorptions from 560 nm to 810 nm. Compared to other types of nanoparticles including spheres and shells, nanorods are more favourable for in-vivo applications due to their tunable optical resonance in the NIR region. Moreover, their relative scattering to absorption contribution can be easily tuned by a change in their dimensions. At present, Nanopartz is the only known commercial source for gold nanorods

## Position Wanted

A recently graduated Ph.D from a US University is seeking a position in industry or academia involving research and development, especially involving nanotechnology and nanoscience. The candidate's interests include synthesis and assembly of nanoscale gold and other metals toward functional nanostructures, and applications in chemical/biological sensing, catalysis, and medical diagnostics. The candidate has extensive skills and experience in spectroscopy, microscopy, electrochemistry, nanoscale synthesis and bioassay techniques. This candidate is a recipient of the prestigious National Science Foundation Graduate Research Fellowship. Available for employment starting around or after July of 2008. Please contact World Gold Council ([industry@gold.org](mailto:industry@gold.org)) in the first instance and your interest will be passed onto the individual.



# Putting Gold Nanorods to Work

Reporting on the PhD projects of Ms Dakrong Pissuwan and Mr Nicholas Stokes – Institute for Nanoscale Technology, University of Technology Sydney, Australia

The optical extinction spectrum of gold nanorods is very sensitive to their shape and, to a lesser extent, their immediate environment. There are two extinction peaks, one corresponding to an electric field oscillation in the transverse direction of the rod, and the other in the longitudinal direction. The longitudinal plasmon mode, in particular, can be readily 'tuned' by control of the rod geometry and environment, and can be moved from the mid-visible to near-infrared. This produces a range of possible transmission spectra, visible to the eye as a range of colours. (Figure 1). For this reason there has been considerable interest in using gold nanorods for optically-selective applications. Two of these potential applications are the subject of current PhD projects at the University of Technology Sydney. The academic supervisors of these projects are Prof. Michael Cortie, and Drs Stella Valenzuela and Andrew McDonagh.

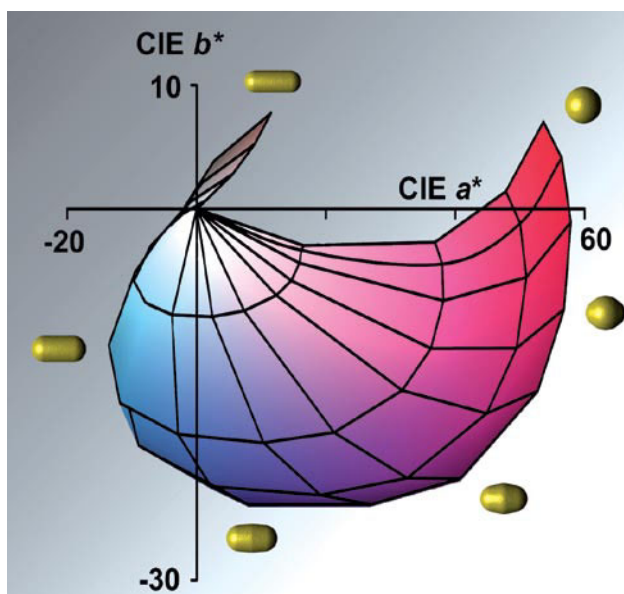


Figure 1. Plot of some of the colours available from colloidal suspensions of gold nanorods, superimposed on the CIE LAB color space. The rod shapes producing the indicated colours are also shown. [Adapted from Xu and Cortie, *Adv. Funct. Mater.*, vol. 16(16), 2006, pp. 2170-2176.].

The longitudinal plasmon resonance of gold nanorods has potential for use in a novel method of photothermal therapy. This idea was pioneered by the group of N. Halas in the USA five years or so ago, and is now being investigated by several groups around the world, including our own. This research has shown how gold nanoshells and rods can be used to kill target cells when illuminated with high power laser radiation. In our own work we extended this concept to demonstrate how gold nanorods can be modified to bind to target macrophage cells which were then destroyed with low power laser illumination. The gold nanorods were

conjugated to CD11b, a monoclonal antibody raised against the murine macrophage cell line, Raw 264.7. The live cells then internalize the gold nanorods, Figure 2, by the process of endocytosis. Irradiation of macrophage cells labelled with gold nanorod-CD11b conjugates at a laser fluence of 30 J/cm<sup>2</sup> resulted in 81% cell death, whereas less than 1% cell death was induced in various controls. This work should provide new possibilities for therapeutic treatment against a wide range of pathogens. The reader is referred to some of our recent publications for further information[1-3].

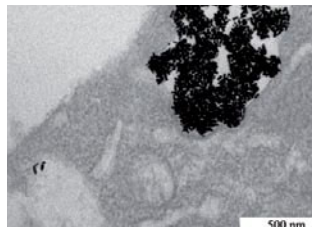


Figure 2. Transmission electron micrograph of a cross section taken from a murine macrophage cell showing gold nanorods inside endocytic vesicles. Photo courtesy of Dr Murray Killingsworth, South West Pathology Service, Liverpool Hospital, NSW Australia.

The longitudinal plasmon resonance of gold nanorods can in principle be exploited to make spectrally-selective coatings for glass windows. This is the basis of the second of the two PhD projects that we present here. Gold rods are used to absorb greater intensities of light at wavelengths designated by their aspect ratio. Figure 3 shows a section of an array of gold nanorods on glass. The ordered arrays were formed using electron beam lithography with gold deposited by evaporation techniques.

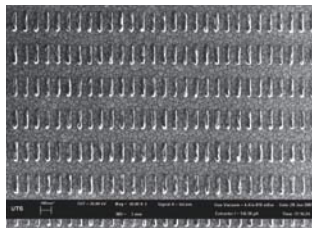


Figure 3. Gold nanorods on glass, produced by a combination of electron beam lithography and physical vapour deposition.

Most current thermal window coatings are based on heat reflection, and use expensive vacuum deposition systems to deposit a thin layer of metal, generally silver. Absorptive coatings an attractive prospect because they are generally much cheaper to produce and have the advantage that they do not reflect heat onto neighbouring buildings. This work is supported by mining company Anglo Gold Ashanti, through a Linkage grant of the Australian Research Council.

Gold nanorods are also an attractive option for window coatings in colder climates, whereby radiation absorbed by the gold nanorods would be convected back inside the building. Use of gold nanorods allows control over the intensity, and wavelength of the radiation absorbed, and window design allows control over the face at which convection occurs ●

## References

- 1 D. Pissuwan, C. H. Cortie, S. Valenzuela & M. B. Cortie, *Gold Bull.*, 2007, **40**, 121
- 2 D. Pissuwan, S. Valenzuela & M. B. Cortie, *Trends Biotechnol.*, 2006, **24**, 62
- 3 D. Pissuwan, S. M. Valenzuela, M. C. Killingsworth, X. Xu & M. B. Cortie, *J. Nanoparticle Res.*, 2007, 1109